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MASTERY LEARNING OF CHEMISTRY COMPETENCIES THROUGH THE SPIRAL PROGRESSION APPROACH IN CURRICULUM

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ABTSRACT

The spiral progression of science competencies for mastery learning in basic education is a major innovation in the new science curriculum in the Philippines. The study assessed the status of mastery learning of Chemistry competencies as a basis for developing and validating Chemistry Instructional Modules.

The status of mastery learning of Chemistry competencies was studied in relation to the respondents' grade levels in the Junior High and their profile (sex, classification of school, type of school, location of school, and teachers' specialization). Correlation analysis identified factors affecting mastery learning. The study employed the quantitative descriptive method using a reliable and valid Chemistry Achievement Test (CAT) administered to Grade 11 STEM strand students from eight science high schools and non-science sigh schools of both public and private schools in the Baguio City-La Trinidad area of the Cordillera Administrative Region (CAR).

Mastery learning of Chemistry competencies in the grade levels revealed an Average Mastery (AM) across all tests. Students from public, science and city schools had significantly higher mastery learning on all four grade levels and overall performance. Correlation results indicate school classification, school type and school location as factors affecting mastery learning. Instructional modules developed and validated were the least-mastered competencies in Grade 9 covering chemical bonding, the mole concept and carbon compounds.

KEYWORDS: Chemistry Achievement Test (CAT), Learning Competencies, Mastery Learning, Spiral Progression Approach & Level of Mastery of Competencies

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Original Article

1. INTRODUCTION

The Spiral Progression Approach is one of the standard principles in the application in the Philippines Enhanced Basic Education Curriculum (K to 12) in the Philippines embodied in Republic Act 10533 (Section 5 of the Enhanced Basic Education Act of 2013). The Department of Education policy guidelines (DepEd Order No.31, s 2012) indicate that the general grades 1 to 10 design follows the spiraling progression of content across subjects, meaning that students learn concepts at a young age and repeatedly learn the same concepts at a higher degree of complexity as they move from one grade level to another. Using the approach to spiral progression enables the learner to learn contents and skills appropriate to the developmental-cognitive stages of the learner. As they are revisited and strengthened, the retention and mastery of topics and skills are also strengthened (Quijano and Technical Working Group on Curriculum, 2012). Repeating the concepts taught in the spiral curriculum leads to mastering a concept based on the previous encounter and building on successive encounters.

Mastery learning in the spiral progression approach covers students' knowledge of facts and data as well as applying of processes and skills. The essence of scientific literacy is mastery learning in the science learning areas like Chemistry where the learner builds higher depth on understanding fundamental science concepts and implementing scientific inquiry skills in as they are learned across the grades. This evidence-based understanding makes the content standards measurable. Learning through the grade level progression paves the way for a deeper understanding of the core concepts and learning competencies expected to be mastered at Grade 10. At the end of Grade 10, students are anticipated to demonstrate their learning competencies critically and creatively in life circumstances.

This is the need of the times in the Philippine educational system. Looking at the big picture, improving basic education by strengthening the curriculum is urgent and critical as the performance of Filipino students in standardized examinations is poor both locally and internationally. Luistro (2010) stressed this by stating that the Filipino students' low performance scores reflect the poor quality of basic education in the Philippines. He also said that many learners who finish basic education do not have sufficient mastery of basic competencies and one reason for this is that students do not receive adequate instructional time.

A National Statistical Coordination Board (NSCB) report on the outcomes of the National Achievement Test (NAT) reiterates that basic education in the Philippines is poor in quality. NAT is a set of standardized tests that address the major subjects taught in school given to Grades 3, Grade 6 and fourth year high school students. A 75 mean percentage score (MPS) is presently set as the goal of DepEd. Results in SY 2004–2005 disclosed that grade six pupils had an average general achievement rate of 58.7%, equal to only near mastery level, whereas fourth year learners had 46.8% or low subjects mastery. While NAT-MPS improved in SY 2011-2012, where the general MPS for Grade 6 was 66.8 and MPS for High School was 48.9, these are still way below the 75 MPS DepEd goal. The Cordillera Administrative Region (CAR) ranked 14 out of 17 regions in the same school year with a general average of 54.5 in grade six NAT while it ranked number 8 with a general average of 49.8 in fourth year NAT. The 2005 to 2012 NAT findings indicate that many learners who have finished basic education do not have sufficient mastery of basic competencies (Mendoza, 2012). Although the SY 2005–2006 passing rate of NAT for grade 6 in SY 2009–2010 (passing rate of 69.21%) has already been improved by 24%, further reforms are needed to achieve substantial improvement. The NAT for high school is 46.38% in SY 2009–2010, a slight decline from 47.40% in SY 2008–2009.

From this big picture to a focus on Science, Bilbao, et al (2015) cited the insufficient mastery of basic competencies of fourth year science students, where most of them belonged to the low mastery category and few were in the near mastery level as revealed in the 2005–2006 Comparative Science Achievement Test. The congested curriculum of basic education is a major factor that was attributed to this dismal performance of graduating fourth year students where insufficient mastery of basic competencies is a consequence.

The National Education Testing and Research Center presented the MPS in Science data for the NAT test in three school years administered to fourth year high school students: SY 2004–2005 with 39. 49%, SY 2005–2006 with 37.98% and SY 2011–2012 with 40.53%. These results show low mastery level in science using the old blocked curriculum with the disciplinal approach. Even the Philippine Science High School's best students have relatively low performance levels in international and national assessment studies. The observation is backed by the outcomes of both the Trends International Science and Mathematics Study (TIMSS, 1999 and 2003) and the National Achievement Test (Department of Education, 2003–2008), as recorded in the "Framework for Philippine Science Teacher Education 2" (2011) of DOST-SEI.

The report also reiterated that while the performance of students in NAT 2007 and 2008 had increased, the national average percentage is still below mastery level.

The result of TIMSS provides an indication of the degree to which students have learned the concepts of math and science studied at school (Lemke, 2006). During the years 1995, 1999 and 2003, series of researches were carried out revealing that in the 2003 TIMSS, Filipino fourth graders ranked 23rd in both Math and Science among 25 nations, while sophomore students ranked 41st in Math and 42nd in Science among 45 nations. Olarte (2006) noted that the Philippines only participated in 1999 and 2003 with scores of 345 and 378, respectively. He also said that the country took part in the Advanced TIMSS 2008 with a score of 355 in which only science high schools students and the elite private institutions in the Philippines participated. The overall scores still fell below the low benchmark of 400. The Olarte report pointed again to the congested curriculum to explain this state of education in the Philippines where the current basic education being delivered in just 10 years, intended for a 12-year curriculum. TIMMS as an international organization evaluates the knowledge and skills in Math and Science of the fourth and eighth graders and closely link the performance of students with the curricula of the participating countries.

The congestion in the Philippine basic education curriculum for many years was seen as the culprit for students not getting sufficient instructional time to understand and master important concepts. For this reason, former President Benigno Aquino signed Republic Act 10533 known as the K to 12 Program implemented in 2013 mandating private and public schools in basic education to use the spiral progression approach in curriculum. The challenge of this significant transformation should be faced by all stakeholders. Even if the reform of education is given with the right prescription but if not properly enforced will easily lead to failure. The transition stage is a significant component of the implementation that is essential for the reform's success so there is a need to pay close attention to the transition phase as this can readily lead to failure if not properly enforced (DOST-SEI, 2011).

It is important to understand the critical role of curriculum in education reform. In their instructional scheme, high performing nations also implement the spiral progression strategy. However, some nations like the United States claim that the approach is not applicable to their learners' needs (Schmidt & Wang, 2005). DepEd sees the approach as a solution to the educational problem in the Philippine setting. The K to 12 Enhanced Basic Education Program features a strengthened Science and Math education using a spiral progression. A major innovation in the science curriculum decongests the competencies and arranges them in a spiral-progressive manner that incorporates the four science disciplines of earth science, biology, chemistry and physics at all grade level. The new science program also shifted from traditional teaching methods to more innovative explorations that use learner-centered approaches using active learning strategies.

A closer focus on the teaching-learning of Chemistry in the spiral progression curriculum emphasizes its holistic and interdisciplinary approach. Chemistry is taught at each grade level with the other science disciplines from Grade 3 through Grade 10. This is to ensure that teaching begins with the basics and as they are taught throughout the grades, these basics become more complex in treatment. This approach enables educators go back to the fundamental concepts at each grade level stage but teach them in increasing sophistication as they go up the grade level (Corpuz and Salandaan, 2015). In particular, students are anticipated to be able to show mastery of learning competencies in Chemistry in terms of knowledge, skills, technology and the development of awareness to practical applications in everyday life. This is contrary to the "blocked" or "massed curriculum" disciplinary approach that introduce difficult concepts when the student has

reached a higher educational level. Students are introduced to chemistry concepts and principles when they reach secondary school in the third year. Consequently, it has been observed that many students who enter tertiary education have poor grasp of chemistry concepts and skills.

Chemistry is one of science's most significant fields that enable learners to comprehend what is happening around them. Since chemistry topics are linked on the structure of matter, chemistry proves a challenging subject for many students. Taber (2002) cited that the chemistry curricula incorporates many abstract concepts that are central to further learning in both chemistry and other sciences. These abstract concepts are essential because it is not easy to understand higher chemistry/science concepts or theories unless the students adequately grasp these fundamental ideas. One of the vital features of chemistry is the steady interplay between the macroscopic and microscopic levels of thinking, and it is in this aspect of chemistry learning that poses a significant challenge to novices. Therefore, learners involve more than once exposure to chemistry concepts, suggesting that learning is improved by re-teaching the chemical concept in different contexts and providing students with different possibilities for learners to practice the new ideas for similar tasks and applying them to daily situations.

One important component within the curriculum for the implementation of the spiral progression of content is the need to address teaching materials, which are often the most tangible and visible aspect of the teaching-learning process. Learning is more meaningful because of the instructional materials that give detailed specification of content. Instructional materials direct teachers to attain the goals and objectives of a specific content or pedagogical task and can greatly help define teaching. In Estonanto's (2017) studies on issues experienced in the implementation of the Senior High School-STEM curriculum, Facility and Instructional Materials were ranked first and second among the six key areas which includes curriculum, learners, faculty, facility, instructional materials and instruction.

Instructional materials development for use in the K-12 curriculum continues to be a challenge. After five years of the K-12 operation, the problem of the lack of instructional materials is still a problem. Modules are among the instructional materials specified by DepEd to support the K-12 curriculum. The modular approach supports the spiral progression approach for they can be designed to begin from the simpler concepts and lead up to more complex ones to be learned. As Guido (2014) points out, learners can continue at their own pace and teacher have more individualized instruction.

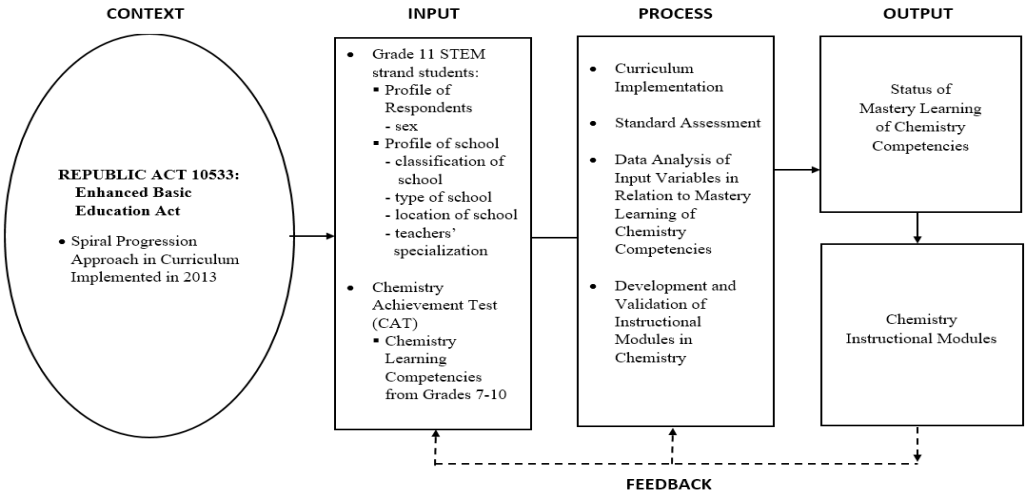

Figure 1: Research Paradigm

2. OBJECTIVES OF THE STUDY

This study assessed the status of mastery learning of Chemistry competencies through the Spiral Progression Approach by Grade 11 STEM strand students in the Baguio-La Trinidad area of the Cordillera Administrative Region (CAR) as a basis for the development and validation of Instructional Modules in Chemistry.

Specifically, the study sought to answer the following questions:

- What is the profile of the respondents in terms of:

a. Sex - male or female; b. classification of school; c. type of school; d. location of school; e. teachers' specialization?

- What is the level of mastery of the respondents on the Chemistry competencies in:

  a. Grade 7; b. Grade 8; c. Grade 9; d. Grade 10?

  - Is there a significant difference between the level of mastery of Chemistry competencies by the respondents among the grade levels?
  - Is there a significant difference between the level of mastery of Chemistry competencies by the respondents in terms of:

  a. classification of school; b. type of school; c. location of school; d. sex?

- Is there a significant relationship between the students' mastery level and the profile of the respondents?
- What are the factors that affect mastery learning of Chemistry competencies?
- What validated instructional modules in Chemistry can be developed to enhance mastery learning of Chemistry competencies?

3. METHODOLOGY

3.1 Research Design

The study employed the quantitative descriptive method. According to Creswell (2012), this quantitative descriptive method involves a survey research using an instrument that collects performance measures through an achievement test; the data collection process includes the following interrelated steps: to determine the respondents to study, to obtain the necessary approval from several people and organizations, to consider what type of information to collect from several accessible sources available, to locate and select instruments to use that will net useful data for research and to administer data collection processes, then descriptively analyze the key trend and variation data reporting measures.

3.2 Sources of Data

The Baguio-La Trinidad area was the concentration of schools which offer the STEM strand in the Cordillera Administrative Region (CAR). The respondents were the Grade 11 Senior High STEM strand learners in both private and public schools in the Baguio-La Trinidad area of CAR, enrolled during the school year 2018-2019 (Table 1). Sampling of four public and four private schools offering the STEM strand had the following clustering: provincial science high, city science high, public schools (city and provincial) and private schools (city and provincial). Total enumeration of

respondents was done from the sample schools. Included in the student answer sheets were the name of the Junior High School where they came from. All respondents who did not move up from the Junior High school of the sample schools were separated from the population. The profile of the respondents as to their sex and school variables was obtained. The profile was correlated to the respondents' mastery learning in Chemistry.

3.3 Instrumentation and Data Collection

A Chemistry Achievement Test (CAT) Questionnaire covering Chemistry learning competencies based from the DepEd Science Curriculum Guide were lifted from K-12 learning modules/materials in Science covering the Chemistry learning area (Asuncion A. J. et al., Campo P. C. et al., Alvarez L. A., et al., Acosta, H. D. et al.,) and K-12 compliant references used by the Junior High School in Science. There were one hundred items in the preliminary draft which was used for the pilot test. Twenty five items of multiple-choice type having four answer options per item were selected from each grade level (Grades 7-10). The pilot test of the CAT questionnaire was done at the University of the Cordilleras among their Grade 11 STEM strand students. The result of the pilot test determined which items were retained, revised or excluded for the final CAT using the Statistical Package for Social Sciences or SPSS. Content and construct validity of the CAT were evaluated by three Chemistry educators composed of the researcher's adviser, the external panel evaluator and an assistant professor in the Chemistry Department of Benguet State University. The validators evaluated the test items to the required content and learning competencies of the K-12 curriculum using the Questionnaires for Evaluation. To further measure the objectivity of the test items, the experts were asked to answer the CAT questionnaire. All suggestions and comments by the experts were included to improve the final CAT questionnaire. The final CAT instrument contained a total of sixty items (60) in consonance with the National Achievement Test (NAT) standard. The questionnaire also contained directions necessary before taking the CAT. The sex profile of the respondents and the profile of the sample schools were placed on the answer sheets. For objective treatment of the results of the study, the names of the schools were coded. A profile questionnaire was also given to all science teachers of the Junior High School of the sample schools. The reliability score of the final instrument using the Chronbach's alpha is 0.81 indicating very high reliability and the validity score from the Chemistry experts is 4.37 indicating very high validity.

Table 1: List of Respondents according to School Variables

Respondents	Population
Public Schools: (4)	
City schools	
A. Baguio City National **Science** High School	51
B. Baguio City National High School Provincial School Provincial schools	77
C. Benguet State University- Secondary Laboratory School	98
D. Cordillera Regional **Science** High School	81
Private Schools: (4)	
City schools	
E. University of Baguio **Science** High School	95
F. University of Baguio High School Provincial schools	99
G. Cordillera Career Development College	78
H. Home Oriented Prime Education- Christian Academy	17
Total	**596**

The valid and reliable CAT was administered to Grade 11 STEM strand students from science high schools and non-science high schools of both public and private schools located in Baguio City and La Trinidad, Benguet of the Cordillera Administrative Region. The STEM strand was chosen for this study because only students in this strand will take Chemistry subjects in the Senior High School. This is also to assure that they have finished the Junior High School (Grades 7-10) which implements the Spiral Progression Approach.

3.4 Analysis of Data

Analysis of the respondents level of mastery of the Chemistry competencies by grade level and over-all performances were obtained by the mean percentage scores (MPS). Comparative results of the Chemistry Achievement Test (CAT) on mastery learning of Chemistry competencies according to classification of school, type of school and location of school were determined by obtaining the mean percentage scores (MPS). F-test (one-way classification Analysis of Variance- ANOVA) for repeated measures was used to test the significant differences between mean scores obtained by the respondents. T-test for two independent populations was used to test the significant differences between mean scores obtained by the respondents according to the variables of sex, classification of school, type of school and school location.

The following descriptive equivalent of scores used to interpret the National Achievement Test (NAT) results were used in the study (Fernandez, 2013):

- 96%–100% Mastered (M)
- 86%–95% Closely Approximating Mastery (CAM)
- 66%–85% Moving Towards Mastery (MTM)
- 35%–65% Average Mastery (AM)
- 15%–34% Low Mastery (LM)
- 5%–14% Very Low Mastery (VLM)
- 0%–4% Absolutely No Mastery (ANM)

The DepEd's mean percentage score (MPS) of 75 percent was used as standard goal for mastery learning.

To determine the correlation between the mean percentages and the profile of the respondents, the Point-Biserial Correlation (r_{pb}) was used. Factors affecting mastery learning in Chemistry have been obtained from these correlation results. These coefficients were then tested inferentially to identify whether they are significantly different from zero (Calmorin, 1994).

Content and construct validation of the instructional modules were facilitated with the help of experts consisting of Chemistry educators and experienced chemistry teachers from the sample schools. Aquino (1997) stressed that it may be necessary to have at least three instrument evaluators to keep the validation process credible. Aquino and Garcia (1974) stated that a good instrument should provide clear, unambiguous, comprehensive instructions so as not to affect validity. Content and construct validation by the experts were evaluated based on the Experts' Evaluation Checklist of Instructional Modules adapted from Marin and Marasigan (2003). Revision of the modules were done according to the recommendations of the experts.

4. RESULTS

4.1 Profile of Respondents

The profile study in reference to the distribution of the 596 respondents showed that there were more female respondents than the male respondents by 11.08% ; the respondents were almost equally distributed in terms of whether they come from public or private schools with a slight difference of 3.02% which was more from public schools; 22.82 % more of the respondents came from non-science schools over science schools while 7.72% more of the respondents came from the city as compared to those coming from the province. The specializations of junior high science teachers of the sample schools were based on a survey conducted. All sample schools have teachers with specializations in all science areas- general science, biological science, chemistry and physics.

4.2 Level of Mastery of Chemistry Competencies by the Respondents in the Different Grade Levels

Schools A and D (Table 1) had the highest MPS ratings of 67.19 and 65.84 respectively in Grade 7 with the descriptive equivalent of Moving Towards Mastery (MTM). The MPS obtained in Grade 7 are higher compared to the other grade levels. The level of mastery in Grade 8 showed Average Mastery (AM) by the sample schools. The highest MPS of 58.69 was from School A, followed by 53.33 MPS from School D and 50.65 from School B. The three schools with MPS above 50 are all public schools. A very similar trend can be observed in the level of mastery in Grade 10 where the three public schools gave the following MPS ratings: 62.35 for School A, 56.28 for School B and 54.81 for School D. In both Grades 8 and 10, only these three public schools had MPS above 50 and the rest of the sample schools had MPS below 50. Among the grade levels, only Grade 9 MPS were below 50 in all the sample schools. This identified Grade 9 learning competencies as least- mastered.

The summary of mean percentage scores (MPS) of the respondents' mastery of chemistry competencies in the different grade level tests showed that the respondents obtained Average Mastery (AM) across all tests. It is also worth mentioning that they had their highest and lowest scores under the grade 7 (MPS of 57.73) and grade 9 (MPS of 37.73) competencies respectively. Analysis of Variance-Repeated reveal that all of the scores are statistically different as indicated by the computed probability value that is less than 0.01. This implies that the students had significantly different level of mastery learning of the four chemistry tests. Since the ANOVA-repeated measures cannot specifically identify which of the four mean scores are significantly different, a post-hoc test was run and revealed that grade 7 MPS of 57.73 is the highest and is significantly different from the rest of the scores. On the other hand, grade 8 and grade 10 scores with MPS of 48.53 and 49.67 respectively reveal from the post-hoc results that they are not significantly different implying that students performed equally under these tests. Finally, the students' collective score under the grade 9 test with MPS of 37.73 is significantly the lowest of all the tests.

Mastery learning of Chemistry competencies by the respondents from the school variables were compared. All grade level MPS are statistically different where students had significantly different level of mastery learning of the chemistry competencies in the grade levels. Overall, the MPS of students coming from public schools at 51.30 is higher compared to 45.15 in private schools. This trend can be observed across all four tests. These differences observed were again subjected to an inferential test called the t-test for two independent samples to identify whether they are significant. All the probability values are less than 0.01 implying that these differences are indeed significant. That is, students coming from the public schools had a significantly higher performance, overall as well as on the four tests of Grades 7, 8, 9 and 10.

Students belonging to science schools had a significantly higher mean percentage score over their non-science counterpart in all grade level tests. This is because all the associated p-values are consistently less than 0.01. Science high schools have a curriculum with more advanced subjects in science and mathematics compared to regular high schools, with the length of time spent on subjects and specific subjects varying by type. In consultation with the Department of Education (DepEd), the Science Education Institute (SEI-DOST) has tailored the curriculum of Regional Science High Schools as well as S&T Oriented High School.

Similarly, the performance of students from city and provincial schools showed that generally, students coming from city schools had higher scores. However, for the grade 7 CAT scores, this observed difference is not significant as indicated by the p-value that is greater than 0.05. This means that students coming from the city schools (MPS of 58.3) performed equally with the students coming from the provincial schools (MPS of 56.87). For the overall performance and the three tests, students coming from city schools had significantly higher scores.

In terms of sex, results reveals that score differences are quite small and inferential tests suggest that these differences are not significant which means that male and female students are at par in terms of their CAT scores.

4.3 Relationships of Mastery Learning of Chemistry Competencies with Profile Variables

The relationship between the students' mastery learning level with their sex variable: male or female and the three school variables: public or private, science or non-science, and city or provincial were determined through the correlation between the CAT scores and the variables under study. Since the CAT scores are continuous, and the identified variables are all dichotomous, the Point-Biserial Correlation Coefficient (r_{pb}) was computed to describe the strength and direction of the relationship among the variables. These coefficients were then tested inferentially to identify whether they are significantly different from zero. Between sex and the CAT scores, there is a negligible correlation as indicated by the coefficients which are almost equal to zero. Results from the inferential test indicated that these coefficients are indeed not significantly different from zero. This implies that the mastery learning of Chemistry competencies of the respondents do not show any difference due to sex. This is true in all grade level competencies and overall performance of the students. Therefore, sex of the students is not a contributing factor in the mastery learning of Chemistry competencies in the spiral progression approach in curriculum.

The correlation between the MPS and the variables under study revealed that the level of mastery of Chemistry competencies did not show any difference due to the sex of respondents which is true in all grade level competencies and overall performance of the students. For the school variables, all of the correlation coefficients suggested negative but significant relationship. The school variables and overall MPS indicated significant tendencies for students coming from a public school, city schools and science schools to get a higher MPS.

4.4 Factors Affecting Mastery Learning of Chemistry Competencies

The results of the correlation study indicate that the school variables which include school classification, school type and school location affect the students' mastery learning of Chemistry competencies. These school variables as contributory factors affecting the mastery learning of students in Chemistry competencies emphasize the important influence of school environment.

4.5 Instructional Modules Developed and Validated for the Least-Mastered Chemistry Competencies

Validated instructional modules were on the least-mastered Chemistry competencies in Grade 9 covering topics on Chemical Bonding, the Mole Concept and Carbon Compounds. These were developed to help enhance mastery learning in the difficult Chemistry competencies.

5. DISCUSSIONS

5.1 Profile of Respondents

The profile of the respondents includes sex, classification of school, type of school and location of school. In terms of sex, there are more females than males which implies that more female students are getting interested in the STEM strand as their field of concentration in preparation to a higher degree of education. The respondents are almost equally distributed in terms of whether they come from public or private schools with a slight difference of 3.02% more from the public schools. The figure reveals the expectation that more parents are sending their children to public schools because of free tuition fee. However, the slight difference can be attributed to the efforts of the government through the voucher program to help parents in continuing to send their children to private schools with a 50% to 100% discount on school fees.

More of the respondents came from non-science schools over science schools. The big difference can be attributed to the entry requirements and retention policies of science high schools. Since schools with a specialized science curriculum are considered as the place for the cream of the crop, registration in these schools usually require passing a competitive entrance examination. Students must also have a grade of at least 85% in Mathematics, Science, and English subjects to enter science high schools, and a grade of at least 83% in all other subjects for the first and second grading periods. In addition, grades lower than the above-mentioned grade qualifications in the subsequent grading periods are grounds for disqualification. Lastly, respondents coming from city schools comprise 7.72% more than those coming from the province. This can be attributed to the fact that Baguio City has more than 200 schools from where parents and students can choose from. According to statistics, Baguio City holds 140,000 students yearly and nearly half of its total population are students that is why it was dubbed as the "education center of the north" (NEDA-CAR, 2010).

The specializations of junior high science teachers of the sample schools were based on a survey conducted. All sample schools have teachers with specializations in all science areas- general science, biological science and the physical sciences (Chemistry and Physics). Interviews done with the principals and science coordinators verified that only science majors among their teachers taught chemistry and the other science areas from grades 7 to 10 in the spiral progression approach of the K-12 curriculum. This is a response to the clamor for improving science education in the country by allowing only qualified science teachers to teach science subjects ("Framework for Philippine Science Teacher Education", 2011).

DepEd Order No. 7, s. 2015 further reinforces for teacher recruitment directed at incorporating and further institutionalizing the primary objective of the K to 12 of RA 10533, which is to improve the general quality of basic education in the nation by employing highly-competent teachers. And to uphold the mandate of the Department under the Magna Carta for Public School Teachers (RA 4670) to promote and improve employment and career opportunities of public school teachers, as well as to attract more qualified teachers to the teaching profession.

5.2 Level of Mastery of Chemistry Competencies by the Respondents in the Different Grade Levels

Schools A and D had the highest MPS ratings of 67.19 and 65.84 respectively in Grade 7 with the descriptive equivalent of Moving Towards Mastery (MTM). Since the Mean Percentage Scores (MPS) shows the ratio between the number of correctly answered items in a test and the total number of items, a 65 MPS in the total test would mean that an examinee correctly answered 7 out of 10 questions in the test (Fernandez, 2013). These 67.19 and 65.84 MPS results brings the schools' performance of mastering the competencies closer to the Dep-Ed target of 75 MPS.

These two schools are public science high schools with science-enriched curriculum and are expected to excel in the science learning areas like Chemistry. The MTM ratings are a level higher than the rest of the sample schools' performance of Average Mastery (AM). The private science high school did not obtain the MTM level with an MPS of 60.07. A 60 MPS in the total test would mean that an examinee correctly answered 6 out of 10 questions in the test (Fernandez, 2013). Since the private science high school did not excel like its science high school contemporaries in the basic Grade 7 competencies, the contributory factors were explored based on the Teachers' Profile and Questionnaires. Two possibilities are teacher experience and availability of existing instructional modules for teaching. The private science high school has younger teachers with the Physical Science teacher recently hired as compared to longer teaching experience of the public science high schools teachers. Kini and Podolsky (2016) noted efficiency improves with experience for most educators with the benefits of teaching experience best realized when they are thoroughly chosen and well prepared as well as intensively mentored and rigorously evaluated over the years. They further reiterated that as teachers gain experience, their students learn more, as measured by standardized tests.

The private science high teachers also reflected in the Teachers' Questionnaire that they do not have existing teaching modules in Chemistry. The Spiral Progression approach recommends the use of teaching modules and other active learning teaching materials to enhance mastery learning, improve critical thinking, and problem solving skills. The K to12 curriculum encourages the development and use of modules which are focused on using student-centered and active learning pedagogies that will strengthen mastery, enhance learning and appreciation of chemistry. The study of Alelaimat and Ghoneem (2012) proposes the necessity to use more modern means to teach science domains to students such as modules strategy. This can be achieved when administrator prioritize training their teachers on modules strategy, and to make available textbook and references which facilities this active learning style of teaching. To maximize the potential of the spiral progression approach with the purpose of preparing students to master higher levels of competencies indicates that schools are to invest in training their teachers to develop, validate and properly facilitate the use of instructional modules and other modern teaching methods that stimulate students' thinking for self- learning.

Compared to the other grade levels, the MPS of grade 7 is higher where seven of the eight sample schools had MPS above 50 which indicates that 30 or more of the 60 items in the CAT questionnaire were correctly answered. While the Grade 7 concepts and learning competencies related to doing scientific investigation and the diversity of materials in the environment (solutions, substances and mixtures, elements and compounds, acids and bases, metals and nonmetals) can be considered as the simplest, it is very important that these basics are mastered through the grade levels as they give foundation to the Chemistry concepts and competencies in the higher grade levels. Deeper grasp of the learning competencies in Grade 7 is imperative for relevant connection in the higher competencies.

The level of mastery in Grade 8 showed Average Mastery (AM) by the sample schools with the highest MPS from School A, followed by School D and School B. The three schools with MPS above 50 are all public schools. A 50 MPS would mean that the students correctly answered 30 of the 60 test items (Fernandez, 2013). As the Table of Specification (TOS) for the final CAT questionnaire represented all the learning competencies according to DepEd TOS requirements, it can be deduced that only the three schools were able to master at least half of the Chemistry competencies covering the concepts of the particle nature of matter, atomic structure and the periodic table.

A very similar trend can be observed in the level of mastery in Grade 10 where the three public schools had MPS ratings above 50. In both Grades 8 and 10, only these three public schools had MPS above 50 and the rest of the sample

schools had MPS below 50. This indicates that only the three public schools correctly answered at least half of the items in the CAT questionnaire and mastering the corresponding competencies while the rest of the sample schools correctly answered less than half of the test items in the CAT questionnaire and mastering lesser of the competencies. Just like in Grade 8, only schools A, B and D were able to master at least half of the Chemistry competencies covering the concepts of the gas laws, biomolecules and chemical reactions. Although all the school samples belong to the Average Mastery (AM) level, a closer study into the MPS scores showed differences in the number of correct items answered and learning competencies mastered. Administrators should continue to encourage teachers to focus in instructional upgrading of mastering all the learning competencies in Chemistry.

Among the grade levels, only Grade 9 MPS were below 50 in all the sample schools which means that the sample schools answered correctly less than half of the CAT questionnaire items. Likewise, as the learning competencies were distributed according to the item analysis and TOS standards, it can be said that the respondents did not master half of the learning competencies covering the concepts of chemical bonding, the mole and carbon compounds. Although the MPS are within the category of Average Mastery (AM), the learning competencies under grade 9 was considered least–mastered due to the fact that less than half of CAT items were answered correctly by all the sample schools. Seven of the sample schools obtained the lowest MPS in all the grade levels. The abstract nature of the concepts of chemical bonding and the mole as well as the immense diversity of carbon compound are attributed to the least mastery of these chemistry concepts and therefore requires more instructional time for conceptual understanding. This abstract nature of chemistry together with the mathematical nature of chemistry) implies that learning chemistry require significant conceptual understandings (Taber, 2002). The challenge in the mastery learning of these difficult concepts is the employment of active learning instructional strategies to maximize the time allotted to learning the competencies. Cognitive science disciplines like Chemistry indicate that classrooms with active learning methods may boost student motivation, retention of information and content transferability (Michael, 2006).

The summary of mean percentage scores (MPS) of the respondents' mastery of chemistry competencies in the different grade level tests obtained Average Mastery (AM) across all tests. The respondents had their highest and lowest scores under the grade 7 and grade 9 learning competencies respectively. ANOVA results reveal that all of the scores are statistically different and implies that the students had significantly different level of mastery learning of the four grade level tests in the CAT. The post-hoc test revealed that grade 7 MPS is the highest and is significantly different from the rest of the scores. On the other hand, grade 8 and grade 10 MPS revealed from the post-hoc results showed that they are not significantly different implying that students performed equally under these tests. Finally, the students' collective score under the grade 9 test is significantly the lowest of all the tests.

The least mastered chemistry concepts in Grade 9 are the learning competencies in chemical bonding, the mole concept and carbon compounds. It could be that the pre-requisite linking knowledge of these concepts were not sufficiently mastered. Sirha (2007) noted chemical bonding, the mole and organic chemistry (carbon compounds) are among the most challenging concepts in Chemistry from the students' perspective that persisted well into university education. For concepts with abstract nature, Taber (2002) proposed more instructional time for better conceptual comprehension in a meaningful manner. Most learners attain mastery if they receive quality instruction and much learning time as the challenging concepts require. The challenge is to provide sufficient time and employing instructional strategies to enable learners achieve mastery learning.

Mastery learning of Chemistry competencies by the respondents from the school variables were compared revealing that the CAT performance comparison of students that come from public schools had higher overall MPS compared to private schools. This trend can be observed across all four tests. These differences observed were subjected to t-test and all the probability values are less than 0.01 implying that these differences are indeed significant. That is, students coming from the public schools had a significantly higher performance, overall as well as on the four tests of Grades 7, 8, 9 and 10.

The better mastery learning of Chemistry competencies by the respondents coming from the public schools can be attributed to the good performance of the public science high schools compared to the private science high school. This is in contrast with the general trends where there were better performances from private schools over public schools. Bernardo, et al. (2015) cited in their studies that learners from public and private schools typically attain different levels of achievement in many different parts of the world, with learners in private schools outperforming their counterparts in various achievement measures. This gap was also observed in the Philippine educational system between public and private schools.

The latest findings show the same trend, and that the advantage of learners from private schools students was observed in all areas of the achievement test. As cited by Bernardo, et. al. (2015), public school learners in the Philippines have lower levels of achievement compared to private school learners due to motivation gap. Their conclusion stated public school learners had less support and assistance for schooling from their social groups, had lower academic related self-concept, and lower achievement goals compared to private school learners. Motivational variables explained a significant amount of variance in achievement and school engagement which showed that learners in private schools tend to outperform their public schools counterparts. They further stated that the availability of funding and infrastructure, among others, contribute to this gap. The study results should encourage public schools to further strengthen the high schools of public science and adopt good practices in the public school system.

Interviews with science heads in public science schools indicated that Dep-Ed bridges the gap in the public schools by requiring the use of classroom evaluation practices with the recent creation of the Learning Action Cell (LAC) which functions as professional learning communities for teachers and aims to develop teachers' formative assessment expertise (Dep-Ed Order No.35, s. 2016). Dep-Ed institutionalized Learning Action Cells (LACs) aimed at developing and supporting effective educators by nurturing their knowledge, attitudes, and competencies in terms of curriculum, instruction, and assessment in their workstations.

In comparing the performance of students grouped according to whether they come from a science or non-science schools, whether they come from a city or a provincial school, and whether they are male or female, the t-test was used which is the same with this study. Clearly, students belonging to science schools had a significantly higher mean percentage score over their non-science counterpart in all grade level tests. Science high schools have a curriculum with more advanced subjects in science and mathematics compared to regular high schools, with the length of time spent on subjects and specific subjects varying by type. In consultation with the Department of Education (Dep-Ed), the Science Education Institute (SEI-DOST) has tailored the curriculum of Regional Science High Schools as well as S&T Oriented High School.

It should be noted that a high school in city science had the highest mean percentage score among the sample schools with a descriptive equivalent of Moving Towards Mastery (MTM), the only sample school that reached this mastery level in the CAT. In perspective of this, as science high schools are expected to perform much better, there may be

a need to re-examine curriculum implementation in other science high schools, which generally performed with average mastery in basic Chemistry competencies. This may reflect of their potential mastery learning in the other science areas. Periodic assessment of the efficacy of the special curriculum being followed in the other Science High Schools (SHS) can be performed to determine the enhancement that would have to be made in "nominal" SHS (Science High School in name only, but not in essence). These schools may also examine the curriculum and practices of the Philippine Science High School (PSHS) and performing regional/city science high schools to improve their performance.

In particular, educational policymakers as suggested by Ogena, et. al., (2010) may draw up a special provision for SHS, specifically an exemption from its current recruiting policy which will enable BS graduates of specialized courses in science and mathematics to teach at the secondary level, such that basic engineering content, for example, will be taught at the secondary level in the proper context.

The sadder predicament of non-science schools in teaching chemistry and the sciences is compounded by the reality of the lack of classrooms, textbooks and learning materials and science laboratories that restrict teachers to lectures and reporting activities instead of laboratory experiments that show how the science concepts work in real life. These limitations in science education lead to lower understanding of science concepts.

Similarly, the performance of students from city and provincial schools generally showed that students coming from city schools had higher scores. However, for the grade 7 CAT scores, this observed difference is not significant as indicated by the p-value that is greater than 0.05. This means that students coming from the city schools performed equally with the students coming from the provincial schools. For the overall performance and the three tests, students coming from city schools had significantly higher scores. The findings are supported by Young's previous research published in 2006 on "Rural and Urban Differences in student Achievement in Science and Mathematics: A Multilevel Analysis" which showed that the school's location had an important impact on student achievement, with learners attending rural (provincial) schools not performing as well as students from urban (city) schools.

The overall impression among researchers, educators, lawmakers, and the general public, that terms of quality of instruction, teachers' training, and schooling conditions, urban schools are well-resourced compared to rural schools. This is in line with that of Karthigeyan and Nirmala (2012) whose findings revealed that urban school learners' academic performance was better than rural schools learners. Strong educational leadership, high expectations, better access to physical/ academic resources and frequent evaluation by teachers described better school success and social adaptation in urban classrooms. A study cited by Owoeye and Yara (2011) examined at the location of schools as it relates to academic performance of students in 50 secondary schools in both rural and urban areas using a validated instrument "Student Location Questionnaire (SLQ)" in Nigeria. The results showed that there were significant differences between learners' academic achievement of rural and urban secondary schools proving that learners in urban areas had better academic achievement than their rural counterpart. The study recommended that government bridge the gap between the rural and urban settings by providing social amenities to rural residents that would improve learners' academic performance. The community should help the government to move teachers and students by making transportation available. The rural area teachers should be given adequate incentives to encourage them to do their best to stay in their duty stations.

In terms of sex, results revealed that score differences are quite small and inferential tests suggest that these differences are not significant which means that male and female students are at par in terms of their CAT scores.

5.3 Relationships of Mastery Learning of Chemistry Competencies with Profile Variables

The Point-Biserial Correlation coefficient between sex and the CAT scores showed a negligible correlation as indicated by the coefficients which are almost equal to zero. This implies that the mastery learning of Chemistry competencies of the respondents do not show any difference due to sex. This is true in all grade level competencies and overall performance of the students. Therefore, sex of the students is not a contributing factor in the mastery learning of Chemistry competencies in the spiral progression approach in curriculum. This corroborates the findings of Agbahe and Awodun (2014) which showed that there was no significant statistical difference in the mean achievement scores of senior high school male and female science students with regard to their achievement mean scores in biology, chemistry and physics whether they come from rural or urban schools. Their findings established the homogeneity of male and female students with regard to academic achievement regardless of variability of the school. They concluded that male and female knowledge base is equal.

For the school variables, all of the coefficients suggested negative but significant relationship. The interpretation of correlation value by Calmorin (1994) shows that between school classification and overall CAT score, there is a low but significant tendency for students coming from a public school to get a higher CAT score. Similarly, the school location (city or provincial) and overall CAT scores indicated the low but significant tendency for students coming from city schools to get higher scores.

Finally, the correlation coefficient between school type and overall CAT score indicated moderate relationship suggesting that there is a moderate and significant tendency that students coming from a science school have higher scores. The results indicate that the school classification, school type and school location can affect the mastery learning of students in Chemistry. This corroborates the findings of Lubienski and Lubienski (2005) who established that learners in public school seemed to outperform their private school counterparts, once learner socioeconomic status (SES) variables were kept constant. The perception that private schools offer better education, environments more conducive to learning, additional resources, and better policies and management practices is challenged especially to parental choice of the less advantaged parents as to where to send their children to school. (e. g., Braun, Jenkins & Grigg, 2006; Lubienski & Lubienski, 2006).

The impacts of school type (public verses private) on learning success were examined and found that private schools may not be as effective as widely thought in providing learning results. For instance, Lubienski and Lubienski as cited by Zhang, Wu and Ma (2014) used hierarchical linear models in examining public versus private performance in reading and mathematics for grades 4 and 8 student. After controlling for student and school-level variables (i. e., socioeconomic status, race/ethnicity, gender, disability, limited English proficiency, and school location), they came to the conclusion that the demographic differences between students in public and private schools accounted for the relatively high raw scores of private schools. Indeed, after controlling for those differences, the private school effect disappeared, and even reversed in most cases. Also, they found that students in private schools show higher overall performance, but this performance advantage vanishes when socio-economic background and initial knowledge as measured in the pre-test scores is adequately controlled for.

Correlation studies of school location on academic achievement of learners in secondary schools revealed that there was statistical significant difference in the achievement scores across subjects while favoring urban schools (Agbahe and Awodun, 2014). This establishes the fact that location of schools is a factor that impacts learners' the academic performance across subjects. The statistically significant differences in learners' science achievement in favor of urban schools as compared to rural schools have been related to differential access to resources required for quality teaching and

learning (Owoeye and Yara, 2011). Learners' academic performance was associated with school environment where the level of academic performance and quality of education may vary as the school environment varied. Low achievement has been reported by urban schools that are big in class size and greater teacher-student ratio while schools with smaller class size and lower teacher-student ratio performed better in public examination. Other factors attributed to differences in academic performances between urban and rural school are in terms school resources adequacy and managerial capacity.

The selective entry of students entering science high schools is a big factor in their better CAT scores. Due to this screening, science high schools provide academic environments which are competitive that aim to produce high-achieving students that foster successful academic results. Based on the level of mastery learning in Chemistry of the respondents grouped according to schools, the two city/regional science high schools gave the highest mean percentage scores. This can be ascribed to the accelerated science curriculum of Regional Science High Schools that differs from Regular High Schools and other Science High Schools in the Philippines. They have access to equipment and facilities for state-of-the-art science education coupled with quality science teachers and instructional materials. These benefits enable them to perform better than non-science high schools or other science high schools.

One of the primary problems facing the Department of Education is the scarcity of science laboratory facilities and equipment where a study undertaken by Versatile Instrumentation System for Science Education and Research project revealed that 23 percent of the public high schools surveyed do not have access to a science laboratory (Dela Cruz, 2017). Weaknesses in this area of science education limits the application of inquiry-approach or project-based learning, the pedagogies in the teaching-learning which leads to mastery of science skills and concepts of learners.

5.4 Factors Affecting Mastery Learning of Chemistry Competencies

Based on the correlation findings of this study, the factors which affects the mastery learning in Chemistry are the school variables. Students coming from public schools had a significant tendency to get higher CAT scores than those coming from private schools. Likewise, students coming from city schools had a significant tendency to get higher CAT scores than those coming from provincial school. Lastly, there is a significant tendency that students coming from a science school have higher CAT scores than those coming from non-science schools. CAT scores are indicative of the mastery learning of the students in the Chemistry competencies implying that the school variables are contributory factors affecting the mastery learning of students in Chemistry competencies. The correlation results emphasize the important influence of school environment. The respondents coming from public science high school located in the city showed the best result of CAT scores indicating the best mastery learning in Chemistry.

5.5 Instructional Modules Developed and Validated for the Least-Mastered Chemistry Competencies

Three instructional modules on the least-mastered Chemistry competencies in Grade 9 with specific content on Chemical Bonding, the Mole Concept and Carbon Compounds were developed and validated. Questionnaires given to the Junior High science teachers of the sample schools showed that these three major topics were among those highly requested as to the modules that needed to be developed in this study. The modules were developed covering the Grade 9 content standards and following Dep-Ed's learning competencies for Chemical Bonding, the Mole Concept and Carbon Compounds. The modules had very high validity results: 4.78 rating for the Chemical Bonding module, 4.82 rating for the Mole module and 4.70 rating for the Carbon Compounds module. The full versions of the three modules after validation were submitted for copyright procedures. The modules adopted the 5-E (Elicit, Engage, Explore, Elaborate, Evaluate) of designing science lessons.

6. CONCLUSIONS

- In relation to the profile of the respondents, the study revealed that sex does not affect the mastery learning of Chemistry competencies but the school variables had affected the level of mastery of the respondents in the spiral progression curriculum implementation.
- The level of mastery of Chemistry competencies through the Chemistry Achievement Test (CAT) is generally Average Mastery (AM). The MPS of Grade 7 MPS are highest and MPS in Grade 9 are the lowest. The identified least-mastered learning competencies are in Grade 9. The respondents who had significantly higher mastery learning of Chemistry competencies in all four grade level tests and overall performance are those coming from public schools which belong to science schools located in the city.
- School variables have significant relationship in affecting mastery learning of Chemistry competencies pointing to factors close to the learning process like schools having quality of teachers, use of science laboratories and more instructional planning in public, science schools located in the city.
- There are varied factors that may affect mastery learning of Chemistry competencies in the spiral progression curriculum implementation and the study revealed school classification, school type and school location as these factors. Mastery learning of Chemistry competencies are in favor of public schools, science schools and city schools.
- The instructional modules in Chemistry developed and validated were the least- mastered learning competencies in Grade 9 covering topics on chemical bonding, the mole concept and carbon compounds. These modules will be recommended for use to private, non-science schools located in the province.

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